SEED AND CONE INSECTS ASSOCIATED WITH *PINUS MONOPHYLLA* IN THE RAFT RIVER MOUNTAINS, UTAH

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Abstract.— Dissection and rearing studies of second-year cones disclosed six species of insects associated with the seeds and cones of singleleaf pinyon pine during the spring and summer of 1976. Those most commonly encountered were: *Dioryctria* sp. probably *albovittella* Hulst, *Conophthorus monophyllae* Hopkins, and *Pineus coloradensis* Gillette. The three remaining species were of lesser importance. These included the gall midge, *Asynapta* sp., a minor cone pest and two parasites, one of *C. monophyllae*, *Acerocephala atroviolacea* Crawford, and an unidentified parasite of *Dioryctria*, of the family Ichneumonidae.

Dioryctria sp. probably *albovittella* was regarded as the major insect destroying cones and seeds of *P. monophylla* in this study. During the growing season it attained a maximum level of 29% infestation. *Conophthorus monophyllae* occurred less frequently in this study, but probably has a higher potential for destruction in years of poor cone crops or high cone beetle populations. *Pineus coloradensis* caused negligible damage to seeds and cones, but was encountered frequently. Early in the growing season it infested a maximum of 38% of the cones.

Insects are probably the most important biotic agents reducing fruit and seed production of trees and shrubs (USDA 1974). This study was conducted to determine those seed and cone insects attacking the cones of the singleleaf pinyon pine, *Pinus monophylla* Torrey & Fremont.

Singleleaf pinyon pine is a member of a group of closely related pines occupying vast acreages in the semiarid regions of the southwestern United States and Mexico (Critchfield and Little 1966). It can form pure, open forests, or, more commonly, grows in association with the Utah juniper, *Juniperus osteosperma* (Torrey) Little, in the characteristic pinyon-juniper woodland (Harlow, Harrar, and White 1979). Pinyon-juniper woodlands cover over 75,000 square miles of the southwestern United States (Lanner 1975), occupying more area in the Intermountain Region than all other forest cover types combined (Cronquist et al. 1972).

Little commercial value has been placed on the pinyon pines for timber products, but the seeds of these pines have been harvested for centuries by American Indians as a valuable food supply (Lanner 1981). Various forms of wildlife depend upon pine nuts for survival, among them many birds and rodents. In good seed years, Indians of the Southwest have collected and sold a million dollars worth of pine nuts. Pinyon timber has also been used for fence posts, mine props, and fuel wood, and pinyons serve as excellent Christmas trees (Johnson 1970).

Since little value is placed on pinyon pines for timber products, there have been few studies describing the insects associated with them. This study was conducted to identify: the major seed and cone insects present on singleleaf pinyon pine, to determine their relative abundance, and to briefly describe their life cycles.

Methods

Study Area

The study area was a 530-hectare singleleaf pinyon–Utah juniper woodland in northwestern Utah's Raft River Mountains at an elevation of 1900 to 2300 m.

Quarter-hectare plots were used to determine the relative number of pinyon pines and junipers. There was an average of 178 pinyon pines and 72 junipers per hectare.

The understory vegetation consisted of big sagebrush, *Artemisia tridentata* Nutt., *Opuntia* cactus, and a variety of grasses and forbs. Toward the western boundary of the stand was an increase in curlleaf mountain mahogany, *Cercocarpus ledifolius* Nutt.

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Sampling

A permanent plot center was selected in a part of the stand found to be typical in terms of overstory density and composition.

Ten sampling dates were scheduled beginning in mid-April and continuing into October at two- to three-week intervals. The permanent plot center was used as a starting point for each collection. Prior to each collection date, a direction was randomly selected and traveled to collect the sample. Any tree falling partly or entirely on the line could be sampled. The restrictions to sampling were that not more than 10% of the sample could come from any one tree and that all cones collected came from unshaded branches of nearly average trees on average sites. Collections were made using a pole pruner and consisted of 100 cones per collection date.

Analysis of the Sample

The sample was returned to the laboratory and cones were grouped based on the exterior appearance of insect damage. Cones showing no exterior evidence of insect activity were also grouped together. Half the cones in the sample were dissected using a cone cutter and the remainder were placed in rearing chambers. Immature insects dissected from cones were recorded and preserved in 70% EtOH for identification by specialists. Rearing of early samples was not attempted, as the small cones dried too rapidly.

Once cones reached sufficient size, emphasis was shifted from dissection to rearing, to obtain adult specimens for identification. Dissection of damaged and normal cones continued using a smaller number of cones to characterize types of damage and to assess the number of individuals attacking a given cone.

Rearing began in July with collection number III. Cones were separated and grouped based on external damage, placed in containers covered with cheesecloth and left at room temperature (18–22 C) (Ebel 1959). Insect specimens collected from rearing chambers, whether adult or immature, were sent to specialists for identification.

RESULTS

The insect species collected and identified from seeds and cones of singleleaf pinyon are listed in Table 1. Following are discussions of the nature of the damage caused by each insect and descriptions of their life histories.

Conophthorus monophyllae Hopkins (Coleoptera: Scolytidae)

Pine cones that dry and wither before they are half grown are said to be "blighted." The usual cause of blighting is pine cone beetle damage by the genus *Conophthorus* Hopk. (Keen 1958). Species in this genus were believed by Hopkins (1915) to be specific to a particular member of the genus *Pinus*. *Conophthorus monophyllae* is a unique species consistently associated with *P. monophylla* (Wood 1982: 984).

The range of *C. monophyllae* would be expected to correspond to that of *P. monophylla*, with the beetle being found wherever the singleleaf pinyon pine occurs. However, collection of *C. monophyllae* in the study area represented an extension of its known range by more than 200 miles (Wood 1982).

TABLE 1. Insects associated with seeds and cones of *Pinus monophylla* in the Raft River Mountains.

Order	Family	Scientific name
Coleoptera	Scolytidae	*Conophthorus monophyllae* Hopkins
Lepidoptera	Pyralidae	*Dioryctria* sp. probably *albovittella* Hulst *Dioryctria* sp. probably *abietella* D. & S.
Homoptera	Adelgidae	*Pineus coloradensis* Gillette
Diptera	Cecidomyiidae	*Asynapta* sp. Loew
Hymenoptera	Pteromalidae Ichneumonidae	*Acerocephala atroviolacea* Crawford One unidentified species

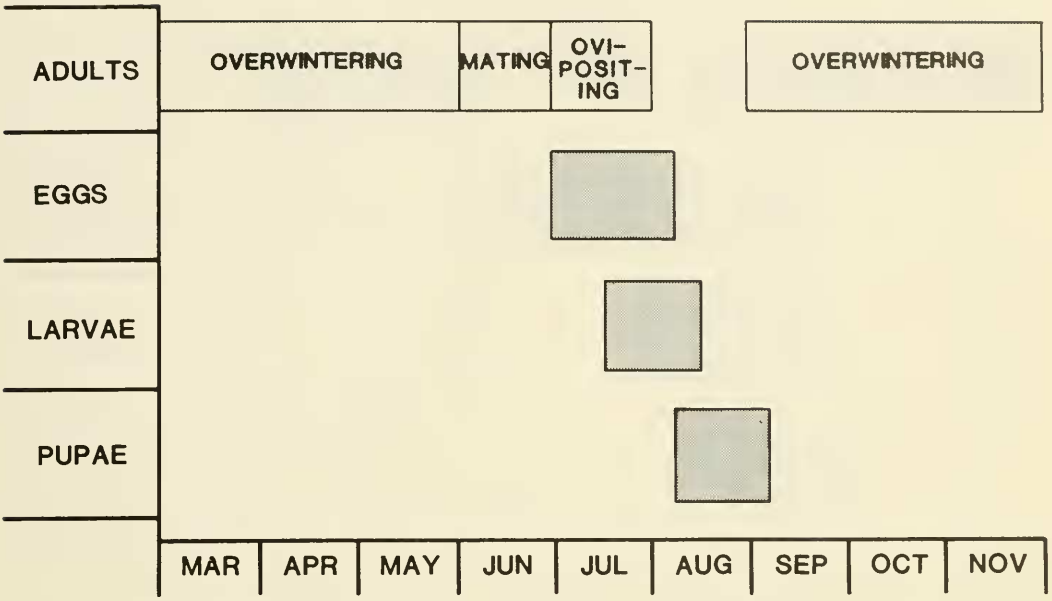

Fig. 1. Life history of *C. monophyllae* showing life cycle stages and their occurrence during the growing season. Adapted from Keen (1958) and field observations.

Life history. Mating occurs in late spring or early summer, and by early July the female beetle lays her eggs in the second-year cones. The cone is killed by the attack of the adult beetle, as she bores a tunnel into the base of the cone and up its central axis, depositing eggs in niches to the sides of the tunnel. The egg niches and tunnel are packed with frass. The first larvae were observed within the cone by mid-July. The larvae feed on the seeds and cone scales, honeycombing the interior of the cone. Pupation occurs in mid- to late August with the adult emerging two to three weeks later. The newly emerged adults overwinter in the dead cone and feed on the drying tissue. They become dormant during the winter and emerge the following spring (Fig. 1). The exact date of emergence will vary with springtime temperatures. There is one generation per year.

Damage. Cones that were attacked by *C. monophyllae* the previous year were readily identifiable by the numerous emergence holes in the cone scales. Previously attacked cones may either remain on the tree or fall to the ground. Old injury was easily found in the study area, although specific counts were not attempted.

Cones that were attacked early in the current growing season were hard, brown, and wrinkled by the end of the season. The entrance hole made by the adult female was visible near the base of the cone, with very little resin or frass present around the hole.

Cones that were attacked later in the season opened prematurely and had an entrance hole near the base. The interior contained larvae, pupae, or adults. Larvae boring in nearly mature cones preferred the individual seeds and were most commonly encountered there with only one larva feeding in any given seed. They reduced the interior of the seed to strips of elongate frass and pupated within the cone. The adult emerged the following spring by way of a hole bored through the cone scale. During the study year, the number of cones attacked by *Conophthorus* did not exceed 11% (Table 2, Fig. 2).

Dioryctria probably *albovittella* Hulst (Lepidoptera: Pyralidae)

Problems were encountered with the identification of the species of *Dioryctria* involved. A long series of larvae was identified by D. M. Weisman as probably being *D. albovittella* Hulst. However, adults that were obtained from rearing chambers containing cones infested with *Dioryctria* sp. appeared to Weisman and D. C. Ferguson to be *D. abietella* D. & S. Weisman and Ferguson

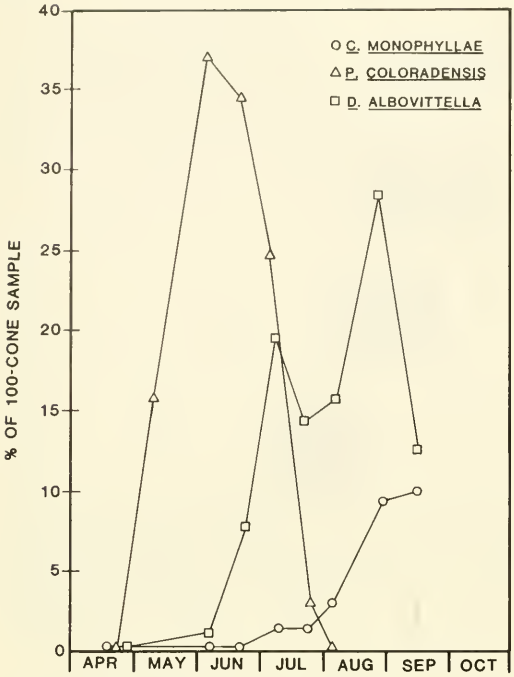

Fig. 2. Percentage of cones attacked by major insect species at various times during the study.

(pers. comm.) believed one of two possible situations existed: the first, and most likely, was a mixed population consisting of *D. albovittella* and a few *D. abietella*. If this was the case, it appeared that the rearing techniques used here might have selected for *D. abietella*. The second possibility was that a new species was involved, which Weisman considered to be unlikely.

The caterpillars of this species of moth fed on the bracts, scales, and seeds of second-year cones, causing blighting, deformity, and sometimes death of the entire cone. Usually a variable percentage of seeds was destroyed and the remainder were unaffected. The activity of these caterpillars was easily identifiable by a large hole in the cone's exterior covered by frass, webbing, and resin (Keen 1958).

Dioryctria albovittella is specific to cones of *P. monophylla* and should be encountered throughout the range of the singleleaf pinyon. The first recorded rearing of *D. albovittella* was from collections made near Topaz Lake, Nevada, in 1939 (Keen 1958). It has a wide host range, affecting a number of coniferous species.

Life history. This species overwinters as eggs laid by females on twigs. The eggs hatch in early spring, and larvae are active in the cones from June through September. Pupae form in sparsely lined pupal cells in July, August, and September. Adults emerge from the cones in August and September. Mating occurs during this period and eggs are again deposited on twigs (Keen 1958; Fig. 3).

Damage. The first larvae were encountered in early July, burrowing in young second-year cones. The activity was evident from a hole covered by frass, webbing, and resin in the exterior of the cone. The frass existed as large spheres, differing from that of *C. monophyllae* described earlier. The gallery within the cone was packed with frass and resin; the tissue immediately adjacent to the gallery dried and turned brown. The caterpillars fed without discrimination on scales and seeds, with only one caterpillar active within any given cone. Small cones attacked early in the season were totally destroyed, but larger cones attacked later showed only partial destruction and could bear some normal seeds and open some scales at maturity (Little 1944).

The first pupae were observed in late July in dry cones. It appeared that the larvae fed for a determinate length of time and then pupated within the drying cone. Pupae and lar-

TABLE 2. Percentage of the 100-cone sample collected on each of the dates shown and attacked by the three most important insect species. Data are shown for various collection dates in 1976. See also Figure 2.

	Collection date								
Species	Apr 18	May 8	Jun 3	Jun 20	Jul 6	Jul 21	Aug 3	Aug 23	Sep 13
D. albovittella	0	0	1	8	20	15	16	29	13
C. monophyllae	0	0	0	0	1	1	3	10	11
P. coloradensis	0	16	38	34	25	3	0	0	0

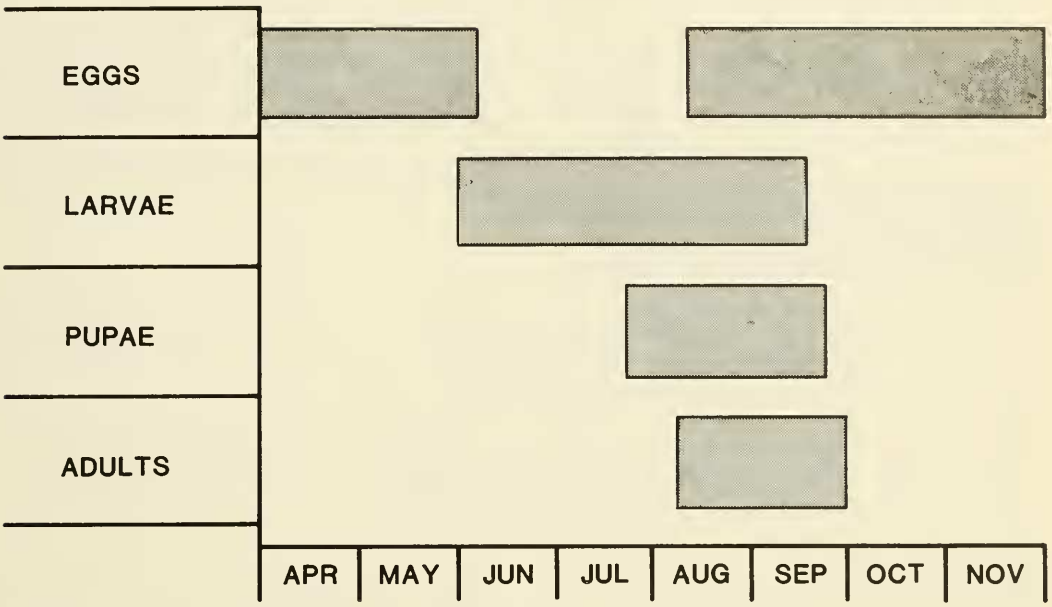

Fig. 3. Life history of *D. albovittella*. Adapted from Keen (1958) and field observations.

vae were collected until the latter part of August.

The percentage of cones attacked ranged from 1% on 3 June to 29% on 23 August. After this time, the incidence of attack dropped off (Figure 2; Table 2).

Pineus coloradensis Gillette
(Homoptera: Phylloxeridae)

Species within the genus *Pineus* form dense mats of wax, often covered by mold, on twigs of ponderosa, Jeffrey, lodgepole, sugar, pinyon, white, and singleaf pinyon pines (Keen 1952). The damage caused by this genus is usually minor, although it can cause unsightliness on ornamentals. A species in the same subfamily, *Adelges cooleyi* Gillette, causes the familiar shoot tip gall seen locally and elsewhere on *Picea pungens* Engelm.

Description. This species is widely distributed throughout the western United States.

Life history. "Few groups of insects have the complexities of life cycle or the varieties of form which are exhibited by the members of the subfamily Adelginae (Annand 1928)." Two different species of conifers are necessary to complete the life cycle. For most members in the genus *Pineus* the primary host is *Picea* (Doane et al. 1936). However, for *P. coloradensis* no alternate host is known. Throughout much of the range of *P. coloradensis*, including the study area, spruces did not occur in large numbers and it is doubtful that the alternate host of this species was spruce. Either another as yet unidentified alternate host existed or the alate forms that migrate to this host failed to become established (Annand 1928).

Several generations, usually five, occur in the life cycle of *Pineus*. Four of the five generations are female only, produced parthenogenetically. Males are produced in the fifth generation (Doane et al. 1936).

Early in the summer, winged females emerged from the primary host and migrated to the secondary host, *P. monophylla* in this case. The first observation of *P. coloradensis* on the cones of *P. monophylla* was made on 8 May. The reddish females established themselves in the crevices between cone scales and secreted a waxy coating. Beneath this wax, the female laid eggs and the eggs hatched into nymphs that fed on the resins of the young cones. There was only one female beneath each wax mass, although many females could become established on a given cone. Thirty-eight percent of the cones in the sample taken on 3 June showed this activity (Table 2). This figure dropped off very rapidly during June and July, and no observations

were made of *P. coloradensis* after 21 July (Fig. 2). Development into alate adults and subsequent dispersion apparently occurred quite rapidly, resulting in this marked decrease in the insect population present on the cones.

Damage. The secretion of wax and ovipositing by females of *P. coloradensis* did no apparent damage to the cones of *P. monophylla* internally or externally. Observations made on cones displaying *P. coloradensis* showed subsequent normal development during the time the insect was present and after it dispersed. Adult females can lay up to 100 eggs, and it has been noted that the feeding activity of immatures on new growth can be harmful, especially to young trees, if the insect is present in abundance (Doane et al. 1936). In the introduction to this section, it was noted that an unsightly condition on ornamentals can result from the presence of species in this and related genera.

Previous reports of this insect have restricted its occurrence to needles and twigs. This study demonstrated that cones represented an important additional habitat.

Other Insects

Three additional insect species were obtained from the cone samples. One was a cone pest identified only to the genus *Asynapta*. The two remaining insects were parasites, one of *D. albovittella* and the other of *C. monophyllae*. The gall midge genus *Asynapta* (Diptera Cecidomyiidae) (USDA 1965) is capable of causing destruction of first-year cones (Felt 1935). First-year cones were not considered in this study, and *Asynapta* sp. was collected from a sample of second-year cones. The limited publications, isolated occurrence, and the fact that only immatures were obtained made it impossible to determine the life cycle or specific identification.

Two parasites were identified. One was an adult specimen of *Acerocephala atroviolacea* Crawford that develops on larvae and pupae of Scolytidae (Clausen 1940), in this case *C. monophyllae*. It has previously been reared from *C. edulis*-infested cones of *P. edulis* at Ute Pass, Colorado, and Las Vegas, New Mexico (Gahan 1946). The other parasite was a member of the Ichneumonidae, which are common parasites of caterpillars. The one reared out in this study was associated with *Dioryctria* sp., but its positive identification was not possible due to the previously discussed problems in identifying the *Dioryctria* sp. found in this study.

Discussion

Very few insect species have been described in association with *P. monophylla*. From the literature, three species have been listed as the most important pests of second-year singleleaf pinyon pine cones. These are, according to Keen (1958), *Conophthorus monophyllae*, *Dioryctria albovittella*, and *Eucosma bobana*. Little (1943, 1944) also emphasized the importance of the genera *Conophthorus* and *Dioryctria* on *P. edulis*. Keen and Little mentioned the activity of unidentified gall midges of the family Cecidomyiidae as having an impact on cone crops, especially on first-year cones.

In this study, *D.* probably *albovittella* and *C. monophyllae* were the most serious pests reducing seed production in *P. monophylla*. The adelgid, *Pineus coloradensis*, was of widespread occurrence, but caused little damage in the study area. The cecidomyiid of the genus *Asynapta* was encountered only once and was considered to be of minor importance. *E. bobana* was not collected in the study area.

Dioryctria probably *albovittella* was widespread and regarded as the most damaging insect species attacking second-year cones of *P. monophylla*. The caterpillars were present and active in cones throughout much of the growing season, feeding without discrimination on all parts of the cone.

The singleleaf pinyon cone beetle, *C. monophyllae*, has a high potential for reducing seed production. Large numbers of offspring developed in and emerged from a single cone. In this study, no cone found to be attacked by cone beetles contained any normal seeds. The incidence of attack in the study area, however, was low, though typical *Conophthorus* populations do increase during years of heavy cone production, then affect a large percentage of cones the following year (Forcella 1980). One significant outcome of

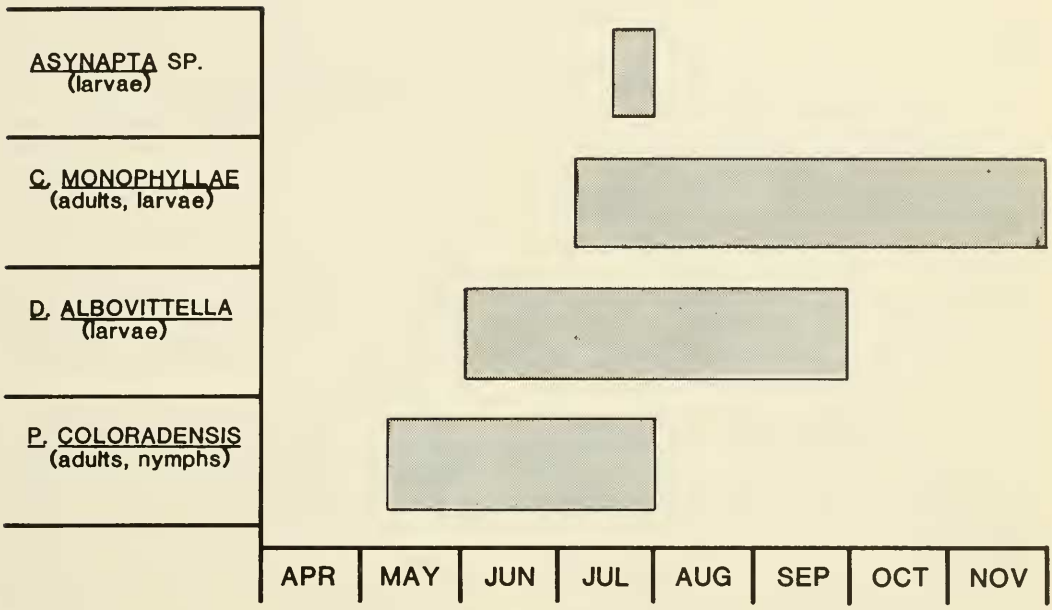

Fig. 4. Time of activity of various insect species during the growing season.

this study was the extension of the known range of *C. monophyllae* by 200 miles.

Pineus coloradensis is a species of minor economic importance. Its collection and identification in this study was of value because it represents the first recorded observation of this insect species on *P. monophylla*. In addition, *P. coloradensis* was not previously reported. Further research on this species in the study area would be valuable in determining the primary host and in obtaining a more thorough understanding of its complex life cycle.

Larvae of the gall midge, *Asynapta* sp., were encountered only once in this study. Keen and Little reported unidentified gall midges of the same family (Cecidomyiidae) as being the most important insects damaging first-year cones, but this study apparently represents the first report of *Asynapta* sp. in the western United States. Because no adults were obtained, identification to the species level was not possible.

Two parasitic insects were also contained in this study. *Acerocephala atroviolacea* was parasitic on *C. monophyllae*. The other parasite attacked *D. albovittella* and could be identified only to the family level. Neither was obtained in abundance and was not believed to be effective in reducing cone beetle or cone worm populations during the year of the study.

There was some correlation between the time of attack by the major insect species and the seasonal history of the cone. *Pineus coloradensis* was most active on the cones during the early part of the season. At this time, the cones were producing the most resin for the adults and immatures to feed upon. *D. albovittella* was active during the early and middle portion of the growing season, when the cones were growing rapidly and were very succulent. Caterpillars can feed on any of the cone tissues during this time. However, by late August, when the cones were reaching maturity, the occurrence of *D.* probably *albovittella* declined sharply. *Conophthorus monophyllae* preferred to feed on the individual seeds within a cone. It did not become active until the cone had matured to the point that individual seeds were evident (Fig. 4).

ACKNOWLEDGMENTS

The author thanks S. L. Wood of Brigham Young University and D. C. Ferguson, R. J. Gagne, E. E. Grissel, M. B. Stoegel, and D. M. Weisman of the USDA Agricultural Research Service, Entomology Research Division, Beltsville, Maryland, for their prompt

identification of the insect species sent to them.

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